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OPERATING EXPERIENCE WEEKLY SUMMARY

Office of Nuclear and Facility Safety

January 23 through January 29 , 1998

Summary 98-04

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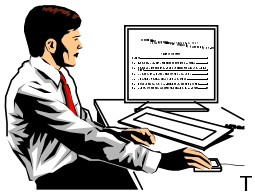

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EVENTS

1. OPERATOR ERROR RESULTS IN A PREMATURE REACTOR PULSE

On January 19, 1998, at the Sandia Pulsed Reactor Facility, an operator error resulted in a premature initiation of a reactor pulse. Two operators were preparing to conduct pulse operations on an experiment package. The operating procedure called for confirmation of reactor pulse element reactivity worth by performing a transient that is super-critical, but slightly below prompt critical. The operators used data from a very similar experiment configuration and pulse conducted in December 1997 to establish the reactor pulse configuration. They recognized that there was a difference in reactivity from the previous pulse, but attributed the difference to an experiment configuration change (additional data cables) that would not impact reactor pulse performance. Instead of a power transient (slightly below prompt critical) the resulting operation was a small pulse (slightly above prompt critical). The Sandia pulsed reactor is designed to be pulsed in a prompt critical condition, so there was no impact to the health and safety of personnel or the environment. The operators' judgment error resulted in a pulse one step earlier in the procedure than intended. (ORPS Report ALO-KO-SNL-6000-1998-0001)

The operating procedure for conducting pulses required the operators to (1) maintain reactor power at a delayed critical setting, (2) determine the reactivity worth of the experiment package, and (3) measure the anticipated reactivity worth of the pulse element. The operators set up the reactor so full insertion of the pulse element would achieve a super critical condition that was slightly below prompt critical to measure the anticipated pulse element reactivity worth. The experiment was vertically positioned in the reactor on a solid aluminum screw-jack with data collection cables connected to it. Investigators determined that a previous test run of this experiment was performed in December 1997, but without active data cables, and may have been positioned using a honey-combed aluminum spacer instead of the screw-jack.

The facility manager convened a root cause analysis team and determined the cause of the event was judgment error. Team members learned that the operators began the experiment late in the day with a desire to complete it to achieve customer satisfaction. The facility manager determined that the operators' desire to complete the experiment may have contributed to their willingness to convince themselves that the reactor reactivity worth changes would not impact pulse element reactivity worth. The facility manager suspended operations while a safety committee and the root cause analysis team further review the event and the associated administrative controls, including experiment configuration changes.

On December 7, 1996, operators at the Sandia National Laboratory violated several technical specifications while operating the annular core research reactor, resulting in a 4-month discontinuation of operations. Investigators determined that operations personnel performed an inadequate reactivity worth measurement because of inattention to detail and inadequate supervision. A DOE Assist Team evaluated this event. They identified additional violations and deficiencies and determined that the operations staff, as well as first-level managers, failed to recognize requirements for implementing technical specifications. (ALO-KO-SNL-9000-1997-0001)

NFS has reported events caused by operator error in several Weekly Summaries. Following are some examples.

- Weekly Summary 97-38 reported that an operator error at the Los Alamos National Laboratory resulted in a scram of the solution high-energy burst assembly during a subcritical operation. The operator failed to verify adequate vacuum in a purge gas accumulator as required by a pre-operational checklist, and a vacuum sensor for the accumulator sent a signal to the scram circuit causing the scram. (ORPS Report ALO-LA-LANL-TA18-1997-0012)

- Weekly Summary 96-13 reported two events at the Savannah River Site, where operator inattention to detail resulted in the inadvertent transfer of nitric acid solution. On March 20, 1996, an operator failed to close the outlet valve of a head tank and allowed 2,200 pounds of nitric acid to transfer to a dissolver before the specific gravity of the acid was verified. The second event occurred on March 25, 1996, when an operator opened a tank drain valve, allowing 600 pounds of nitric acid to transfer to a waste header, while performing a valve lineup for a frame waste recovery run. (ORPS Reports SR--WSRC-FCAN-1996-0005 and SR--WSRC-HCAN-1996-0009)

These events illustrate the importance of operator attention to detail. Workers must assume responsibility for their work and pay attention to detail without rushing to meet real or informal deadlines. In addition, operators are typically trained to approach criticality using the “half-way” rule. This rule delineates that no single step (or reactivity addition) shall change reactivity by more than half-way to criticality or that no single step addition shall double the multiplication factor. NFS advocates self-checking, a risk management tool designed to reduce the potential for human error. Self-checking requires distinct thought and actions that focus attention at a specific moment before performing a task.

These events also underscore the importance of operators being aware of system configuration changes. Operations personnel should periodically review standing orders, work packages, and system changes to determine if operational requirements are affected. Experiment procedures must be changed, reviewed, and approved when configuration changes are made. Facility managers should ensure that subject matter experts review changes before they are implemented. Facility managers in charge of operations personnel should ensure that operators review configuration changes, perform independent verifications, identify off-normal conditions, and take appropriate corrective actions.

- DOE O 5480.19, *Conduct of Operations Requirements for DOE Facilities,* chapter XIII, “Operations Aspects of Facility Chemistry and Unique Processes,” states that operators should be knowledgeable about facility processes and safety issues that affect operation and should be able to recognize off-normal situations and take actions to correct any problems.

- DOE/EH-0502, Safety Notice 95-02, “Independent Verification and Self-Checking,” describes a technique that requires workers to (1) stop before performing the task to eliminate distractions and identify the correct component; (2) think about the task, expected response, and actions required if that response does not occur; (3) act by reconfirming the correct component and performing the function; and (4) review by comparing the actual versus the expected response.

- DOE/NS-0012, Safety Notice 92-06, “Estimated Critical Positions,” describes operator errors in estimated critical positions due to incorrect assumptions, incorrect calculations, lack of awareness of the reactor condition, operator inattention, and inadequate procedures.

Safety Notices can be obtained by contacting the ES&H Information Center, (301) 903-0449, or by writing to ES&H Information Center, (800) 473-4375, or by writing to U.S. Department of Energy, ES&H Information Center, EH-72, 19901 Germantown Road, Germantown, MD 20874. Safety Notices are also available on the OEAF Home Page at http://tis.eh.doe.gov:80/web/oeaf/lessons_learned/ons/ons.html.

KEYWORDS: operations, reactor, experiment, critical

FUNCTIONAL AREAS: Nuclear/Criticality Safety, Operations

2. SPENT FUEL SHIPPED WITHOUT O-RINGS INSTALLED ON CASK PLUG COVERS

On January 9, 1998, a reactor operator at the Oak Ridge High Flux Isotope Reactor did not install O-rings on three plug covers for a spent fuel cask. Research Reactors Division personnel shipped the cask containing a spent fuel element to the Savannah River Site on January 14. On January 22, operators at Savannah River discovered the O-rings were missing and reported this to Research Reactors Division personnel. Savannah River operators inspected the cask on receipt, but saw no evidence of leakage. Investigators believe that the process used to independently verify installation of the O-rings may not have been followed. This event is important because shipping spent fuel in a cask without the O-rings installed represented an instance in which conditions of approval in the Nuclear Regulatory Commission (NRC) certificate of compliance were not observed when making the shipment. (ORPS Report ORO--ORNL-X10HFIR-1998-0003)

Operators loaded a spent fuel element into the spent fuel cask on January 9 and successfully performed a required leak test before shipment to Savannah River. Operators at Savannah River off-loaded the spent fuel for storage. During disassembly of the cask, they discovered that the required O-rings were missing from covers for the cask drain plug, cask vent plug, and cask leak-test plug. The covers and O-rings do not constitute the cask primary containment.

Research Reactors Division personnel discussed the issue with the cask manufacturer. The manufacturer also holds the NRC certificate of compliance that allows transportation of spent fuel over public roadways in the cask. Manufacturer representatives determined that the absence of the O-rings did not conform to the NRC certificate. They are determining the applicable reporting requirements.

The facility manager held a critique with personnel who loaded the cask. Critique members determined that personnel did not follow the procedure steps for installation of the O-rings and plug covers. While loading the spent nuclear fuel, a reactor operator performed the steps on the cask inside a contamination area, while an engineer read the procedure steps from outside the contamination area. The engineer also performed the function of independent verifier and was required to verify the installation steps. One procedure step required the operator to install and snug the leak test plug and vent plug. The next step

required the operator to install the O-rings and install and snug the plug covers. The engineer observed the operator from outside the contamination area and did not enter the area to physically verify that the plugs and plug covers were snug. The engineer also did not have the operator initial the procedure steps until the next day. Critique members continue to investigate and finalize their report for this event.

Facility personnel will review the procedure to determine if the steps require revision. The action steps may need to be re-written to direct installation of O-rings as one step and installation of the plug covers as another.

NFS has reported numerous events in the Weekly Summary where a breakdown in the independent verification process occurred. The following are some examples.

- Weekly Summary 97-50 reported that an operator at the Savannah River L-Reactor installed a lockout on the wrong lockout point for maintenance on a compressed air system. The independent verifier failed to catch the lockout error. Investigators determined that inattention to detail on the part of the operator and the verifier was a causal factor because the system drawings, valve labels, and lockout order were all correct. (ORPS Report SR--WSRC-REACL-1997-0013)

- Weekly Summary 96-50 reported that a mechanic at the Savannah River In-Tank Precipitation Facility lifted and taped an incorrect lead while installing a lockout. An operator installed a tag on the lead and signed the lockout and another operator verified and initialed the lockout step was correct. Investigators determined that the independent verification process did not work because the second operator was not qualified to identify the correct tag point. (ORPS Report SR--WSRC-ITP-1996-0042)

This event illustrates the importance of performing proper independent verification, which is the practice of having a qualified person other than the person who performed the task check it for conformance to established criteria. Also, procedures should be written with clear action steps, and communication between a procedure reader and performer should include "repeat backs" of information. Communication can also be enhanced if the instruction is followed by a confirmation of completion; such as "install the O-rings," followed by "the O-rings are installed." DOE-STD-1029-92, *Writer's Guide for Technical Procedures*, provides guidance for writing basic action steps in section 4.1 and for writing action steps containing verifications in section 4.9. DOE-STD-1031-92, *Guide to Good Practices for Communications*, provides guidance for repeat back and confirmation in section 4.1, "Oral Instructions and Informational Communications."

DOE-STD-1036-93, *Guide to Good Practices for Independent Verification*, section 4.3, "Verification Techniques," discusses two types of verification techniques. The first technique involves checking the final condition or position of components against a standard. This is typically done when personnel establish a lockout/tagout or align a system for operation. A performer positions a component and a verifier positively checks that the physical position is correct. The second technique is used when a specific process or series of sequential steps are performed. Because verification that the steps were performed correctly may be impossible by observing the finished product, this technique involves observing that the proper steps, sequence, or adjustments are performed according to a standard. This is typically done when installing a cover on a piece of equipment where bolts must be installed

and torqued to a certain value. In all cases, the instructions should minimize the interaction between the performer and the verifier to preserve the independence of each.

DOE/EH-0502, Safety Notice 95-02, "Independent Verification and Self-Checking," presents lessons learned about the necessity of properly performing independent verifications. Safety Notice 95-02 can be obtained by contacting the ES&H Information Center, (800) 473-4375, or by writing to U.S. Department of Energy, ES&H Information Center, EH-72, 19901 Germantown Road, Germantown, MD 20874. The Safety Notice is also available on the Operating Experience Analysis and Feedback Home Page at http://tis.eh.doe.gov:80/web/oeaf/lessons_learned/ons/ ons. html.

KEYWORDS: cask, communication, independent verification, procedures, shipping, spent fuel

FUNCTIONAL AREAS: Operations, Procedures

3. REPAIR OF INTERNALLY CONTAMINATED VACUUM PUMP SPREADS CONTAMINATION

On January 20, 1998, at the Los Alamos National Laboratory, a researcher contaminated his shoes and spread contamination in a laboratory at the Radiochemistry Site while repairing a vacuum pump. The researcher did not know the pump was internally contaminated with technicium-99 when he disassembled it. Contamination on the researcher's shoes measured up to 140,000 dpm/100 cm^2 beta-gamma. A radiological control technician surveyed the laboratory and found oily spots on both the floor and a countertop that measured from 130,000 to 260,000 dpm/100 cm^2. He determined that the contaminated oil came from the pump. The radiological control technician posted the laboratory room to control access until it could be decontaminated. Investigators determined that the researcher did not have the oil sampled or the pump internals surveyed for contamination during disassembly, which resulted in the spread of contamination. (ORPS Report ALO-LA-LANL-RADIOCHEM-1998-0001)

Investigators determined that the researcher decided to disassemble the pump to assess possible modifications for improving its performance. He donned a lab coat, safety glasses, and vinyl gloves before disassembling the pump. The researcher drained oil from the pump into a secondary containment on the floor and moved pump parts to a countertop during disassembly. At the conclusion of his work, he self-surveyed before exiting the radiological control area, as required by procedure, and detected contamination on his personal shoes. He remained in the room and immediately called the radiological control technician, who confirmed contamination on both shoes. Facility personnel did not detect any activity on the nasal smears submitted by the researcher. The radiological control technician took smear samples from the shoes for analysis. Analytical results showed 2.1 nanocuries of technetium-99.

The facility manager conducted a critique of the event on January 22. Critique members determined that the pump must have been used for technetium work before it was transferred from another facility that was in transition because no technetium work was ever performed in the laboratory. Surveys showed the exterior of the pump was clean, and personnel believed it came from a clean area. However, there was no history on this pump, and it was not labeled as being contaminated or potentially internally contaminated. The researcher applied the safety consi-derations addressed in the Laboratory's integrated safety

management program, but he did not have the pump oil sampled for contamination or have smears or surveys performed on the pump internals. Critique members also identified a weakness in the procedure for handling radioactive material, which did not require sampling or surveying suspect equipment in controlled areas before opening or disassembly. When opening a piece of equipment in a controlled area, personnel should always assume it is contaminated until proven otherwise. A corrective action will require radiological control technicians to survey vacuum pumps for contamination. If the surveys are positive, they will label the pumps contaminated; if the surveys are negative, they will label the pumps suspect.

NFS reported the following events where personnel did not consider internal contamination of equipment in the Weekly Summary.

- Weekly Summary 97-43 reported that shippers at the Los Alamos Accelerator Complex shipped vacuum pumps that contained residual oil contaminated with tritium to an off-site company for maintenance. The company did not know the pumps were contaminated and did not have radiological controls to work on the contaminated pumps. Investigators determined that shippers removed the pumps from a controlled area and shipped them off-site without proper controls and labeling. (ORPS Report ALO-LA-LANL-ACCCOMPLEX-1997-0014)

- Weekly Summary 97-25 reported that a researcher at the Los Alamos National Laboratory received an uptake of plutonium-239 and spread contamination when he performed unauthorized maintenance on a vacuum valve. The researcher removed the valve stem without a radiation work permit or a safe operating procedure, and the area work supervisor was not aware of the work. The researcher believed he could repair the valve problem himself, and he never considered that the valve internals or the inside of the evacuation system would be highly contaminated. (ORPS Report ALO-LA-LANL-TA55-1997-0027)

These events underscore the importance of surveying contaminated or potentially contaminated equipment before handling, disassembly, or shipment. This is particularly important when the history of the equipment is unknown. Also, radioactive material that has been surveyed for release should be properly tagged or labeled. Personnel who need to remove radioactive material from controlled areas should contact radiological protection personnel for release surveys and authorization. DOE/EH-0256T, *U.S. Department of Energy Radiological Control Manual*, provides direction on marking, monitoring, and controlling radioactive materials. Chapter 4, part 1, “Radioactive Material Identification, Storage, and Control,” provides guidance for labeling radioactive material.

- Section 411, “Requirements,” states that any equipment or system component removed from a process that may have had contact with radioactive material should be considered contaminated until disassembled to the extent required to perform an adequate survey and show the component or equipment to be free of contamination.

- Section 412, “Radioactive Material Labeling,“ states that radioactive material outside contamination, high contamination, or airborne radioactivity areas shall be labeled in accordance with Table 4-1 of the manual.

Equipment, components, and other items with actual or potential internal contamination should be labeled "CAUTION, INTERNAL CONTAMINATION" or "CAUTION, POTENTIAL INTERNAL CONTAMINATION." Labels should include contact radiation levels, removable surface contamination levels (specified as alpha or beta-gamma), dates surveyed, surveyor's name, and description of items. Items that are too small to be labeled with all of the stated information should be labeled, at a minimum, with the words "CAUTION RADIOACTIVE MATERIAL" and the standard radiation symbol.

KEYWORDS: contamination, internal contamination, labeling, pump, survey

FUNCTIONAL AREAS: Radiation Protection

4. ELECTRIC SHOCK EVENTS AT SANDIA NATIONAL LABORATORY

This week OEAF engineers reviewed two recent events at the Sandia National Laboratory, where personnel received electric shocks. On January 16, 1998, at the Tube Test Area, a technician received an electrical shock while replacing a test circuit. Technicians had installed the test circuit the previous day. They tested it, found a malfunctioning part, and decided to replace it. While removing the suspect part, one technician received a shock. Investigators determined that because of a two-point failure of a path leading to ground (loss of both leads to ground), the tester had a floating charge. On January 22, 1997, at the Sandia Lightening Simulator, a technician received an electrical shock while trouble-shooting a trigger circuit on a Mini-Marx generator. The technician checked several system components, including capacitors, and determined that a component had not malfunctioned. When he began cleaning the support fixtures, he received a shock. Investigators determined that the technician failed to install a jumper cable on the pulse-forming network capacitor before cleaning the generator. Investigators determined that the procedures the technicians used did not provide detailed steps or instructions for the work being performed. Although, investigators are continuing to review these events, they have determined that work control weaknesses resulted in electrical shocks and could have resulted in personnel injuries. (ORPS Report ALO-KO-SNL-14000-1998-0001 and ALO-KO-SNL-9000-1998-0002)

The DOE facility representatives and the facility managers held a meeting and discussed these events. They determined that five similar events have occurred at the Laboratory over the last 2 years. Employees involved in all five events were performing open test set-up work around high voltage that contained pulse-forming network capacitors. According to the investigators, the following three issues are common to all of the events. (ALO-KO-SNL-1000-1996-0002, ALO-KO-SNL-14000-1996-0004, ALO-KO-SNL-1000-1997-0002, ALO-KO-SNL-1000-1997-0005, ALO-KO-SNL-1000-1997-0008)

- Inadequate Procedures—The procedures were modified after each event to provide additional details to workers.

- Unknown Energy Status—Workers either did not know that the capacitors were charged, did not realize they were working with high voltage, did not have a complete understanding of the system limitations, or were confused by several workers making multiple equipment status decisions.

- Inadequate Work Planning—Investigators determined that workers assigned to the jobs were not adequately trained in three of the events; the job scope or design changed in two of the events; and work hazards during planning were not addressed in one of the events

Both facility managers discontinued open test set-up operations in their facilities until a root cause evaluation is completed and additional corrective actions can be developed.

NFS has reported similar electric shock events at Sandia in the Weekly Summary. Following are some examples.

- Weekly Summary 97-45 reported that a technician received a shock from a partially charged capacitor when he removed a cable from a fixture in a fluorinert-filled test tank. The technician inadvertently touched the coax connector shell at one end of the cable to a resistor in the circuitry while his hand was on the tank. This completed the circuit to ground and allowed the capacitor to discharge. Investigators determined that a designer added the capacitor to upgrade the system 3 months earlier and did not revise procedures to reflect the upgrade. (ORPS Report ALO-KO-SNL-1000-1997-0008)

- Weekly Summary 96-51 reported that a technician received an electrical shock when his right hand came close to a high-voltage bank of capacitors. The network contained 14 capacitors connected in parallel creating a 4,200-volt potential. The discharge path through his body was from the bottom of his right wrist to his elbow at the point where it was in contact with the grounded metal chassis. Investigators determined that there were no provisions to discharge capacitors before performing work and that the procedure lacked details. (ORPS Report ALO-KO-SNL-14000-1996-0004)

Corrective actions for the events reported in the Weekly Summary included modifying the procedures involved in each event to better reflect hazards controls and incorporating an integrated safety management system process into each procedure. This process includes planning the scope of work, identifying the associated hazards, and determining methods needed to control the hazards before work is performed.

OEAF engineers reviewed selected occurrences from the ORPS database from October 1, 1990, through January 30, 1998, for hazardous electrical occurrences and found 743 reports. More than half of the occurrences had a root cause of either management problems or personnel error. About 28 percent of the management problems resulted from inadequate administrative control; 25 percent resulted from inadequate policy dissemination and enforcement; and about 24 percent resulted from work-planning deficiencies. About 41 percent of the personnel errors involved procedure not used or used incorrectly, and an additional 41 percent were reported as inattention to detail. Taken together, the data indicates that nearly 72 percent of all occurrences could be eliminated by a well-trained, well-managed, attentive work force using good procedures. Figure 4-1 shows the distribution for hazardous electrical occurrences.

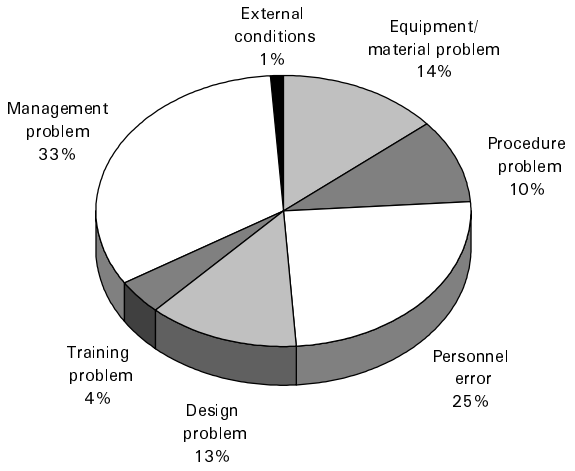

Figure 4-1. Root Causes for Hazardous Electrical Occurrences[1]

These events illustrate the importance of understanding capacitor circuits, attention to detail, use of grounding devices, use of lockouts and tagouts where appropriate, personnel training, and labeling of hazards. The probability of craftsman error increases with the use of poor or incomplete procedures. Procedures should provide technical guidance to workers to help ensure that work is accomplished in a systematic and correct manner. This guidance must be technically accurate, complete, and up-to-date and must be presented in a clear, concise, and consistent manner that minimizes human error.

Managers and supervisors in charge of job performance should ensure that hazards are identified and corrected. DOE facility managers should ensure that personnel understand the basics of work control practices and safety and health hazard analyses. Personnel in charge of system design changes should ensure that facility documentation, including procedures and drawings, is updated and accurate. Managers and personnel in charge of writing procedures should review the following documents to ensure that procedures contain appropriate levels of detail.

- DOE O 4330.4B, *Maintenance Management Program,* chapter 6, provides guidance for preparing and using procedures and other work-related documents that contain appropriate work directions. Section 6.2 states that experience has shown that deficient procedures and failure to follow procedures are major contributors to many significant and undesirable events.

- DOE-STD-1029-92, *Writer's Guide for Technical Procedure*, provides guidance for the preparation of procedures used at DOE facilities. This standard states that tasks associated with testing equipment and systems must be defined in the procedure to ensure safe and efficient operation within the appropriate margins of safety. Section 4.1 discusses the basic elements of writing action steps; section 4.10 discusses how to include warnings, cautions, and notes in procedures.

[1] OEAF engineers performed several interactive narrative searches for electrical events. Review of the reports identified 743 reports that we classified as hazardous electrical occurrences.

- OSHA regulations in 29 CFR 1910.147, sub-part J, “General Environmental Controls,” and in 29 CFR 1910.333, sub-part S, “Safety-Related Work Practices,“ require discharging, short-circuiting, and grounding capacitors if stored electric power could endanger personnel.

- DOE/ID-10600, *Department of Energy Electrical Safety Guidelines*, chapter 2.0, states that capacitive devices may retain or build up a charge, so the circuit should be shorted or grounded.

- DOE-STD-1073-93-Pt.1 and-Pt.2*, Guide for Operational Configuration Management Programs, Including the Adjunct Programs of Design Reconstitution and Material Condition and Aging Management*, provides guidelines and good practices for an operational configuration management program including change control and document control.

- The *Hazard and Barrier Analysis Guide*, developed by OEAF, discusses barriers that provide controls over hazards associated with a job. Barriers may be physical barriers, procedural or administrative barriers, or human action. The reliability of barriers is important in preventing undesirable events such as shocks. The reliability of a barrier is determined by its ability to resist failure. Barriers can be imposed in parallel to provide defense-in-depth and to increase the margin of safety. The *Hazard and Barrier Analysis Guide* provides a detailed analysis for selecting optimum barriers, including a matrix that displays the effectiveness of different barriers in protecting against some common hazards.

A copy of the *Hazard and Barrier Analysis Guide* is available from Jim Snell, (301) 903-4094. A copy may also be obtained by contacting the ES&H Information Center, (800) 473-4375, or by writing to U.S. Department of Energy, ES&H Information Center, EH-72, 19901 Germantown Road, Germantown, MD 20874.

KEYWORDS: capacitor, electrical, shock, circuit

FUNCTIONAL AREAS: Industrial Safety, Configuration Control, Hazards and Barrier Analysis, Electrical maintenance

5. CEILING TILE REMOVAL RESULTS IN VIOLATION

On January 19, 1998, a Rocky Flats Plutonium Processing and Handling Facility shift technical advisor discovered that subcontractor construction workers had removed ceiling tiles from around sprinkler heads without implementing compensatory measures, resulting in an operational safety requirement violation. Subcontractor personnel removed the ceiling tiles to install overhead electrical conduit based on a guidance letter instead of a formal work document and did not initiate a fire watch. Investigators determined that removing the ceiling tiles could have affected fire suppression system operation because the sprinkler heads are suspended below the ceiling and the tiles act as a heat reflector to ensure that the sprinkler heads activate in the event of a fire. Facility personnel replaced the ceiling tiles. The system remains inoperable until integrated systems services personnel perform post-maintenance testing. The facility manager terminated all limiting conditions for operations and potential

fire-producing activities. He also implemented a fire watch. Failure to perform work to a formal work document resulted in an operational safety violation and could have resulted in the lack of fire detection and suppression in the event of a fire. (ORPS Report RFO--KHLL-371OPS-1998-0005)

Investigators determined that the subcontractor construction manager approved the ceiling tile removal based on a guidance letter written by fire protection engineers. They also determined that the guidance letter indicated that the fire protection system would be impaired. The letter also stated that the building operations manager should be contacted before tile removal to determine if a stationary or roving fire watch was needed. The subcontractor construction manager believed the letter authorized the work, so he gave copies of the letter to the building manager and shift manager and began the work. Investigators determined that both managers believed that the letter was for information only and did not take any action.

The facility manager held a fact-finding meeting. Meeting attendees learned that the ceiling tiles were removed in November 1997. They also learned that this was the second occurrence in which work was performed to a guidance letter instead of a formal work document. The first occurrence was approximately two weeks earlier. Corrective actions for that occurrence included development of a lessons learned document regarding the importance of not performing work without technical reviews and evaluations. This corrective action is scheduled for completion in February. (Weekly Summary 97-49 and ORPS Report RFO-KHLL-371OPS-1997-0099). The facility manager directed facility personnel to perform the following corrective actions.

- Incorporate the guidance letter work controls into the subcontractor's work package.

- Train building managers and supervisors on: (1) the acceptable documents for performing work; (2) how to recognize work control steps included in guidance letters that should be in approved work control documents; (3) the relationship between ceiling tiles, fire protection, and the building authorization basis; and (4) the importance of not performing work to letters or memoranda.

- Train fire protection engineering personnel to prepare guidance letters that do not authorize work.

- Train subcontractor personnel on not performing work based on guidance letters.

The facility manager also directed facility personnel to issue a site-wide lessons learned document on this event. DOE personnel questioned the effectiveness of the corrective actions implemented following the first occurrence. DOE engineering personnel will continue to evaluate corrective action effectiveness for events that involve the lack of formal work controls.

NFS has reported inadequate work controls in several Weekly Summaries. Following are some examples.

- Weekly Summary 97-49 reported that a construction worker at the Rocky Flats Plutonium Processing and Handling Facility completely severed an energized 120-volt line while core-drilling a concrete wall. Investigators determined that

the subcontractor construction manager approved the core-drilling based on an exemption letter written by engineering personnel and without a technical review. They also determined that the construction manager failed to obtain engineering personnel approval before starting the core-drilling activities. The facility manager directed engineering personnel to rescind all facility exemption letters. (ORPS Report RFO--KHLL-371OPS-1997-0099)

- Weekly Summary 97-03 reported that a building manager at the Rocky Flats Environmental Technology Site found several external electric circuit breaker operators (handles) that had been replaced without authorization or the required planning and coordination with other building activities. Investigators found no authorization to perform the work and determined that written procedures for the work were not available or not used. (ORPS Report RFO--KHLL-NONPUOPS1-1997-0002)

- Weekly Summary 96-47 reported that on November 13, 1996, at the Hanford Analytical Laboratory, a subcontractor diesel mechanic removed a run-hour meter from an operating diesel, causing the diesel and a diesel-operated exhaust fan to stop. The mechanic performed the work without authorization or an approved work package. (ORPS Report RL--PHMC-ANALLAB-1996-0004)

OEAF engineers reviewed the ORPS database for work control events and found 1,750 reports with 1,990 nature of occurrences. Figure 5-1 shows that facility managers reported that 54 percent of these events affected the facility condition. Further review shows that 24 percent of the facility conditions were reported as vital system/component degradation, 23 percent were reports as violation/inadequate procedures, and an additional 22 percent were reported as operations.

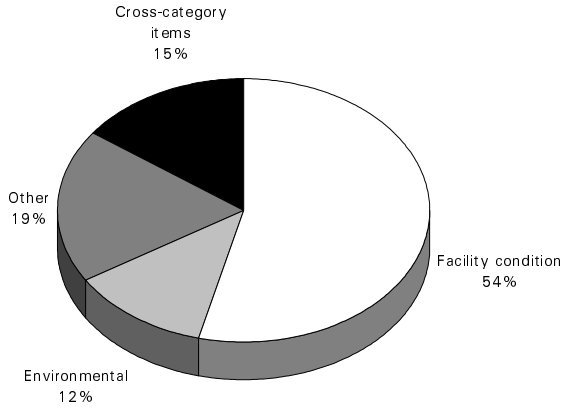

Figure 5-1. Nature of Occurrences for Work Control Events[2]

[2] OEAF engineers searched the ORPS graphical users interface database for reports with a root cause of "6B" (work organization/planning deficiency) and found 1,750 reports with 1,990 nature of occurrences.

These events underscore the importance of four critical work control elements: (1) clear work control procedures for implementing construction work; (2) communication between work planners and working groups to ensure that activities are specifically identified in work packages and appropriate limits are defined; (3) proper implementation of corrective actions; and (4) the necessity for facility managers to ensure that contractors understand and follow work control programs. Proposed modifications to a system need to be thoroughly reviewed, and the impact of other systems on the design basis should be evaluated. If the corrective actions from the first event had been correctly determined and properly implemented, the latest event might not have occurred. Also, the construction manager believed that the guidance letter authorized removal of the ceiling tiles. This is an indication that facility management may have failed to adequately communicate work control mechanisms and their importance to the contractor and subcontractor. Facility managers are ultimately responsible for ensuring successful completion of work activities. Routine monitoring of contractor and subcontractor work by facility managers and supervisors will help ensure that maintenance activities are conducted in accordance with facility policy and procedures.

Many DOE Orders, standards, and guidelines addressing work control programs, training, conduct of operations, installations, independent verifications, and the adequacy of technical staff are applicable to this event. Facility personnel responsible for work that is performed by subcontractor personnel should clearly understand their responsibilities. Facility managers should ensure that work controls are rigorous enough to allow workers to complete jobs safely and efficiently without relying solely on communications. Facility personnel responsible for corrective action programs should ensure that corrective actions are effective in preventing recurrence.

- DOE O 4330.4B, *Maintenance Management Program,* chapter 15, "Management Involvement," identifies the degree of management involvement in oversight and approval of maintenance activities. Chapter II, section 8.3.1, "Work Control Procedure," states that work control procedures help personnel understand the necessary requirements and controls. Section 8.3.6, "Control of Non-facility Contractor and Subcontractor Personnel," states that contractor and subcontractor personnel who perform maintenance or modifications on facility systems should be trained and qualified for the work they are to perform. This section also states that contractor and subcontractor personnel should receive training on (1) facility administration, (2) safety, (3) quality control, (4) radiation protection procedures and practices, and (5) general employee training.

- DOE-STD-1004-92, *Root Cause Analysis Guidance Document,* chapter 6, "Corrective Actions," states that proposed corrective actions should be (1) reviewed to ensure the appropriate criteria are met, (2) prioritized based on importance, (3) scheduled, (4) entered into a commitment tracking system, and (5) implemented in a timely manner. It states that a complete corrective action program should be based on specific causes of the occurrence, lessons learned from other facilities, appraisals, and employee suggestions. It also states that a successful program requires management involvement at the appropriate level and willingness to take responsibility and allocate adequate resources for corrective actions. Chapter 8, "Follow-Up," provides information on following up on corrective actions to determine if they have been effective in resolving problems. It states that corrective actions should be tracked to ensure they have been properly implemented and are functioning as intended. It also states that the recurrence of the same or similar events must be

identified and analyzed and, if the same or similar event recurs, the original occurrence should be investigated to determine why corrective actions were not effective.

- DOE-STD-1050-93, *Guideline to Good Practices for Planning, Scheduling and Coordination of Maintenance at DOE Nuclear Facilities*, section 3.1.1.3, provides the key elements of an effective planning program. Included is guidance on consistency in planning between disciplines to avoid confusion and frustration in work groups. The standard also discusses the need for thorough reviews of work packages by experienced individuals to eliminate errors.

- DOE-STD-1051-93, *Guideline to Good Practices for Maintenance Organization and Administration at DOE Nuclear Facilities*, section 2.3.8, "Non-Facility Personnel," states that when non-facility personnel are used, the duties, authorities, responsibilities, and functional interfaces with personnel should be clearly defined. Section 4.3.4, "Management Control of Plant Configuration," provides guidance to ensure plant configuration is maintained and conforms to established design bases.

KEYWORDS: fire protection, work control, operational safety requirement

FUNCTIONAL AREAS: Work Control, Licensing/Compliance, Lessons Learned

6. IMPROPERLY WIRED SAFETY SHUT-DOWN DEVICE RESULTS IN COMPRESSOR DAMAGE

On January 19, 1998, personnel at the Mound Tritium Emissions Reduction Facility reported that damage to a compressor that failed last October may have occurred because a low oil pressure switch was mis-wired. They found the mis-wired switch while repairing and inspecting the failed compressor. Investigators determined that the acceptance testing procedures were inadequate because they lacked any requirements to test safety shut-down devices for the compressor. The mis-wiring and failure of the safety shut-down device to perform its intended function resulted in extensive damage to the compressor. (ORPS Report OH-MB-EGGM-EGGMAT01-1998-0001)

Investigators reported that the compressor automatically shut down on October 8, 1997, and an operator restarted it. However, he heard loud knocking noise coming from the compressor, so he shut it down manually. Following the shut-down, mechanics completely disassembled and inspected the compressor. During their inspection they identified the mis-wired switch.

Investigators believe that the extent of damage to the compressor was because the cut-out switch failed to shut it down on a loss of oil pressure. They have not determined the cause for the original shutdown. They are also trying to determine if the operating contractor was recording daily pressure checks and performing preventive maintenance as recommended by the manufacturer.

NFS has reported on similar occurrences involving inadequate acceptance testing in the Weekly Summary. Following are some examples.

- Weekly Summary 97-12 reported that a construction welder at the Savannah River Site identified a weld on a tank that did not appear to comply with design drawings. Investigators determined that neither the tank manufacturer's quality assurance program nor the code inspector's review identified the welding deficiency. (ORPS Report SR--WSRC-CMD-1997-0004)

- Weekly Summary 93-29 reported that event evaluators at the Savannah River Site F-Canyon determined that the root cause of a generator failure was a management problem involving a deficiency in work organization and planning. The evaluators determined that if maintenance personnel had established a more extensive installation acceptance test program, they could have detected the problem with the generator. (ORPS Report SR--WSRC-FCAN-1993-0034)

OEAF engineers searched the ORPS database for occurrence reports that contained the string "acceptance test" in the cause narrative and found 66 reports containing 67 events. A review of these reports found 16 occurrences that would have been avoided if acceptance testing was properly performed. Most of these occurrences involved degradation of safety systems or unplanned power outages.

These events underscore the importance of prudent inspections and testing of equipment or systems upon receipt and after installation. Procurement organizations should not rely totally on the manufacturer's or installer's quality assurance program, unless they audit the program or participate in the inspection process. Design and procurement specifications should specify what level of receipt inspection is prudent and take into account the extent to which potential suppliers have been qualified as "evaluated suppliers." Acceptance testers may find it necessary to have subject matter experts assist them with examining and testing equipment.

DOE 5700.6C, *Quality Assurance*, specifies the criteria for procurement and the criteria for inspection and acceptance testing. These criteria discuss controls for selection, determination of suitability, evaluation, receipt of purchased items, and for evaluation of prospective suppliers. The Order specifies periodic monitoring of suppliers and sub-tier suppliers, if applicable, to ensure that acceptable items and services continue to be supplied. The inspection and acceptance testing criterion states that a process should be established and implemented to specify when to inspect procured items and what type of inspection is required. Guidance for receipt inspections can also be found in DOE-STD-1070-93, *Guidelines to Good Practices for Procurement of Parts, Materials, and Services at DOE Nuclear Facilities*, and DOE-STD-1071-94, *Guidelines to Good Practices for Material Receipt, Inspection, Handling, Storage, Retrieval, and Issuance at DOE Nuclear Facilities*.

KEYWORDS: procurement, inspection, certification

FUNCTIONAL AREAS: procurement

7. INSTRUMENT AIR LINES SEVERED DURING EXCAVATION

On January 13,1998, at the Hanford Site, excavators severed instrument air lines while using a truck-mounted auger to collect soil samples, causing supply and exhaust fans at the Waste Encapsulation and Storage Facility to shut down. One exhaust fan remained running

throughout the event, maintaining negative pressure at the facility. Personnel at the sampling site stopped work and notified the team coordinator. Facility managers assembled an overtime crew that made temporary repairs to the severed airlines and returned the facility ventilation systems to service in approximately 2 hours. No personal injuries and no radiological or environmental releases occurred as a result of this event. (ORPS Report RL--PHMC-WESF-1998-0002)

Facility managers conducted a critique of this event. Attendees determined that facility personnel scanned the area to locate air lines in the vicinity using gamma-penetration scanners. They also determined that attendees at the pre-job meeting discussed the possibility of hitting unidentified lines and reviewed prints showing the approximate position of the air lines. However, facility project planners incorrectly assumed that the air lines were metallic and would show up on the gamma scan. Excavators augered the soil sampling hole, believing that the gamma scan showed that the air lines were not inside the sampling area. There were 12 plastic air lines encased in an outer plastic tube at a depth of approximately 4 feet. The auger severed the outer tube and several of the air lines.

NFS has reported on excavation occurrences in several Weekly Summaries. Following are some examples.

- Weekly Summary 97-44 reported three events involving inadequate work controls and pre-job planning for excavation activities. At the Hanford Site, a plant maintenance worker received a slight shock from a heat-traced line while excavating a potable water line. At the Idaho National Engineering Environmental Laboratory, a construction worker struck and damaged an energized 480-volt cable with a backhoe, interrupting power to three buildings. At the National Institute for Petroleum and Energy Research, a construction worker severed a natural gas line with a trenching machine, resulting in evacuation of the area. (ORPS Reports RL--PHMC-KBASINS-1997-0023, ID--LITC-LANDLORD-1997-0017 and HQ--GOPE-NIPER-1997-0005)

- Weekly Summary 97-33 reported four events involving improper excavation. At Hanford, a subcontractor performing renovation activities in a building basement cut a conduit containing an energized 110-volt line. At Lawrence Livermore National Laboratory, a contractor cut an underground energized 480-volt line while using construction equipment to loosen the soil surface. At the Hanford Waste Encapsulation and Storage Facility, a back-hoe operator performing excavation activities severed an abandoned underground telephone line. When work resumed on the next day, the back-hoe operator severed an abandoned, de-energized electrical cable. (ORPS Reports RL--PHMC-WESF-1997-0007, RL--PNNL-PNNLBOPER-1997-0023, and SAN--LLNL-LLNL-1997-0051)

- Weekly Summary 96-42 reported that jackhammer operators struck three conduits while working on a concrete dock inside a building at the Rocky Flats Environmental Technology Site. The subcontractor assumed that the prime contractor had verified that no utilities were located beneath the concrete. (ORPS Report RFO--KHLL-REGWSTOPS-1996-0005)

- Weekly Summary 96-04 reported that a mason tender at Los Alamos National Laboratory received a severe electrical shock that resulted in serious burns and cardiac arrest. The mason tender was excavating in a building basement when the jackhammer he was operating contacted an energized 13.2-kV

electrical cable. (Type A Accident Investigation Board Report on the January 17, 1996, Electrical Accident with Injury in Building 209, Technical Area 21 Los Alamos National Laboratory; ORPS Report ALO-LA-LANL-TSF-1996-0001)

These events underscore the importance of using effective work control practices, detailed pre-job planning, and conservative assumptions. Pre-job briefings, facility procedures, and training programs should emphasize the dangers associated with excavation activities and the importance of locating existing utilities. This occurrence might have been prevented if the gamma-penetration scanner had been used to identify the location of the instrument air lines instead of using it to verify that lines were not present inside the sampling area. Facility personnel responsible for excavation safety may consider using vacuum excavation techniques when in the vicinity of utilities. Following are some references that facility managers, program and project managers, trainers, and project personnel should review for excavation guidance.

- DOE/EH-0541, Safety Notice 96-06, "Underground Utilities Detection and Excavation," provides descriptions of recent events, an overview of current technology for underground utility detection, specific recommendations for improving site utilities detection and excavation programs, and information on innovative practices used at DOE facilities.

- DOE-STD-1050-93, *Guideline to Good Practices for Planning, Scheduling, and Coordination of Maintenance at DOE Nuclear Facilities*, provides information on work controls and work coordination.

- 29 CFR 1926, *Safety and Health Regulations for Construction*, paragraph .965(c) states that work must be conducted in a manner to avoid damage to underground facilities.

Information on industry state-of-the-art techniques for underground utility detection and excavation techniques, including vacuum excavation, may be found at the Underground Focus Home Page at URL http://www.underspace.com.

Safety Notice 96-06 can be obtained by contacting the ES&H Information Center, (800) 473-4375, or by writing to U.S. Department of Energy, ES&H Information Center, EH-72, 19901 Germantown Road, Germantown, MD 20874. Safety Notices are also available on the OEAF Home Page at http://tis.eh.doe.gov:80/web/oeaf/lessons_learned/ons/ons.html.

KEYWORDS: construction, excavation

FUNCTIONAL AREAS: Construction, Industrial Safety, Hazards Analysis, Work Planning